EOS, Transactions, American Geophysical Union   Vol. 64, No. 47, Pages 945–952   November 22, 1983

Particles and Fields—Interplanetary Space

5330 Electromagnetic radiation
THE IO DECAMETRIC EMISSION CONE
J. L. Green (Space Science Laboratory, NASA/Marshall Space Flight Center, Huntsville, AL 35812)

The Planetary Radio Astronomy experiment or PRA onboard Voyager 1 and 2 observed intense Jovian decametric (or DAM) radiation from Jupiter for several months before and after encounter with the giant planet. As measured by the PRA experiment the DAM emissions from 2 to 40 MHz have a characteristic 'arc' like shape in frequency versus time spectrograms. Much work has already been done relating observations of DAM emission with the position of the satellite Io. The PRA data are reorganized in this study in order to account for the relative positions of Io and Jupiter and to aid in determining the causes of the DAM 'arc' like structure. Nearly 2 months of the PRA data were transformed into a coordinate system for which Io and Jupiter remain fixed and the spacecraft data are sorted into bins of spacecraft System III (65) longitude. A $1/R^2$ normalization factor is applied to all the sorted data to take into account the radial distance dependence of this emission. The results of this sorting technique indicate that the Io-dependent DAM emissions, as seen by both Voyagers 1 and 2, are generated in hollow cones at all frequencies over the fixed Io longitudes studied (from 200 to 260 degrees). Comparing the characteristics of the DAM emission at the 'edges' of the emission cones (in two ranges of spacecraft longitude), distinct differences can be found. In addition, the edges of the emission cones are, in many cases, broad in longitude (30 degrees or more).

Three-dimensional ray tracing calculations within a model Jovian magnetosphere are used in an effort to explain the shapes of the DAM emission cones. Using a general emission mechanism which ultimately generates radiation in the R-X mode above the R=0 cutoff, qualitative agreement with the observations can be seen which indicate that the observed 'arc' structure is largely a propagation effect. The greatest bending of the DAM model rays occurs on one 'edge' of the emission cone and is almost entirely due, at frequencies below 25 MHz, to the large region of enhanced (above dipole) magnetic field believed to exist around 195 degrees. Enhanced plasma densities found in the Jovian ionosphere may produce an additional propagation effect at frequencies greater than 25 MHz.

Sci. Sci., Paper 3S1596

Particles and Fields—Ionosphere

5505 Airglow
TIME-VARIATIONS IN THE OXYGEN RED LINE INTENSITY IN THE SUBTROPICAL NIGHTGLOW ANOMALY
[illegible]

Particles and Fields—Magnetosphere

5755 Plasma instabilities
ANOMALOUS TRANSPORT BY MAGNETOHYDRODYNAMIC KELVIN-HELMHOLTZ INSTABILITIES IN THE SOLAR WIND-MAGNETOSPHERE INTERACTION
Akira Miura (Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Calif. 90024)

[illegible]

5755 Plasma instabilities
ELECTROSTATIC ION CYCLOTRON WAVES IN MAGNETOSPHERIC PLASMAS: NON-LOCAL ASPECTS
[illegible]

Physical Properties of Rocks

6110 Elasticity, fracture and flow
EXPERIMENTAL DEFORMATION OF POLYCRYSTALLINE H₂O ICE AT HIGH PRESSURE AND LOW TEMPERATURE: PRELIMINARY RESULTS
W. B. Durham and H. C. Heard (University of California, Lawrence Livermore National Laboratory, Livermore, California 94550), and S. H. Kirby
[illegible]

Acid Rain: Controllable?

Lester Machta
Air Resources Laboratory, National Oceanic and Atmospheric Administration, Rockville, MD 20852

Introduction

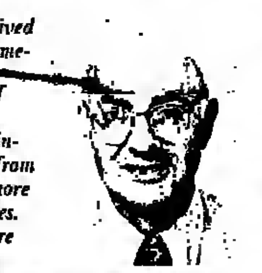
Acid rain is one of a growing number of environmental issues in which impacts are far removed from the source of the irritants. Those who suffer may differ in geographical area from those who benefit from the activity which releases pollution to the atmosphere. Like the issue concerning the depletion of ozone by manufactured chemicals, the acid rain issue further emphasizes the need for continuing atmospheric chemistry research, a science whose history dates back but a few decades. Examination of the acid rain issue also calls for intimate collaboration of atmospheric scientists with ecologists, biologists, and other scientists, who must advise the geophysicists regarding what chemicals in the environment produce damage, their mode of entry into an ecosystem, and the need to understand acute or chronic impacts.

The general public believes acid rain produces ecological damage and should be stopped. The atmospheric transport, chemistry, and removal processes are known very imperfectly and thus one may justify or reject the public's belief depending on the data one selects. To try to resolve the scientific uncertainties, the federal and state governments, private organizations, and many foreign countries have mounted major research efforts. The federal government, for example, has doubled its acid rain expenditures between 1980 and 1983. From the perspective of an atmospheric scientist, what may be involved in preventing acid rain?

Acidity Widespread

According to conventional wisdom, distilled water in the presence of atmospheric CO_2 would produce carbonic acid with a pH of 5.6, and therefore any precipitation with a pH below 5.6 should be viewed as acid rain and, by implication, caused by humans. In the past few years, sufficient measurements have been made at remote locations to indicate that rarely is the pH equal to 5.6, and when it is, the equality is fortuitous. More often, the pH of precipitation is well below 5.6. For example, the average amount-weighted pH of precipitation at the National Oceanic and Atmospheric Administration's Mauna Loa Observatory in Hawaii, whose elevation is more than 3500 m, is near 4.3. In and downwind of arid regions such as the western United States, the pH might well be above 7.0.

An explanation for the occurrence of low pH rain in areas remote from manufactured atmospheric pollutants was given by *Charlson and Rhode* [1982]. The negative ions usually associated with the acidity of precipitation in remote places are sulfate rather than nitrate, but in some areas organic ions may be equally important. The sulfate may have come via long-range transport from distant, man-made sources or from naturally occurring sources such as ocean biota. This relatively new finding leads to the unanswered question: What would be the acidity of precipitation in eastern North America in the absence of any man-made sources?



Lester Machta received his M.S. and Sc.D. in meteorology from M.I.T. in 1948. He is director of NOAA's Air Resources Laboratory, where his interests span the range from radioactive fallout to more current air quality issues. He is the author of more than 75 articles and a member of many national and international committees.

Control Possibilities

The usual approach to assessment of benefits from emission control scenarios relies on models which purport to simulate the transport, the chemical transformations, and the deposition of acidic materials, especially on ecologically sensitive areas. With few exceptions (*Rhode et al.* [1981] is one of them), the chemistry involved in the models requires only first order kinetics in predicting the transformations of SO_2 to $SO_4^=$ and NO_2 to NO_3^-. There appear to be grounds for arguing that these conversions may not be linear since the oxidation involves trace oxidants and catalysts that are not necessarily always present in adequate concentrations. We can't be certain of the exact details because the chemistry that takes place within a cloud droplet or ice crystal is difficult to study, yet is thought to be an important part of the transformation. The consequence of possible nonlinear chemistry in the acid rain issue means that a reduction in emissions from a specific area might not result in a proportional decrease in deposition from that source. A linear response is predicted from most existing acid rain models.

To overcome many of these problems, it has been suggested that a large field experiment might be mounted which, in one fell swoop, would link source and receptor. Both the U.S. Environmental Protection Agency and the private Electric Power Research Institute are exploring this possibility with preliminary ideas expected in perhaps a year from now. This writer and others believe that the most promising of these experiments would be a trial emission variation in which an area would first deliberately reduce SO_2 emissions to below-average levels and then raise them to above average; accompanying these changes would be measurements of corresponding changes in downwind deposition. This experiment has several practical problems, including potentially very high cost, since it would have to be conducted long enough for statistically valid results to be obtained; a need for cooperation from utilities; and an extensive monitoring network (including measurements of dry deposition).

Patterns of hydrogen, sulfate, and nitrate ion deposition in rural precipitation show a maximum in Ohio, Pennsylvania, and adjacent areas. This region lies within and immediately downwind of the areas of most intense SO_2 and NO_x utility and industrial emissions, causing a very highly suggestive association between emission and deposition. The hydrogen and sulfate ion concentration and deposition in precipitation exhibits a seasonal variation, with higher values in the warm season; nitrate fails to follow any marked seasonality. Longer-term time trends in acidic deposition are greatly hampered by the poor or uneven quality of most observations prior to about 5 years ago. Nitrate concentration in northeastern U.S. precipitation appears to be increasing slightly while sulfate is decreasing. Both of these trends agree qualitatively with emissions of SO_x and NO_x during the past decade in nearby regions, but the trends in the concentration of hydrogen ion during the same period are less clear. Unfortunately, we are unable to measure the deposition of any of these chemicals adequately during dry weather with a network of samplers. It is believed, however, that a significant fraction of the total deposition occurs as dry deposition.

The scientific community recognizes that there are major uncertainties in our knowledge of the geophysical aspects of acid rain. But few, if any, scientists will deny that man-made emissions of SO_x and NO_x contribute to or are the main cause of the acid rain phenomenon in eastern North America. Where many do disagree is in the confidence that should be placed in predicting the benefits of a given emission control scenario. Many believe that present levels of acid deposition are now damaging the environment and might be inclined to take the risk that an overly conservative scenario would be chosen. Others might argue that the increased damage over the next years while better knowledge is gathered would be small, particularly in contrast to increased costs to consumers. To my knowledge, all scientists, politicians, environmentalists, and industrial managers agree on the need to resolve the uncertainties as soon as possible.

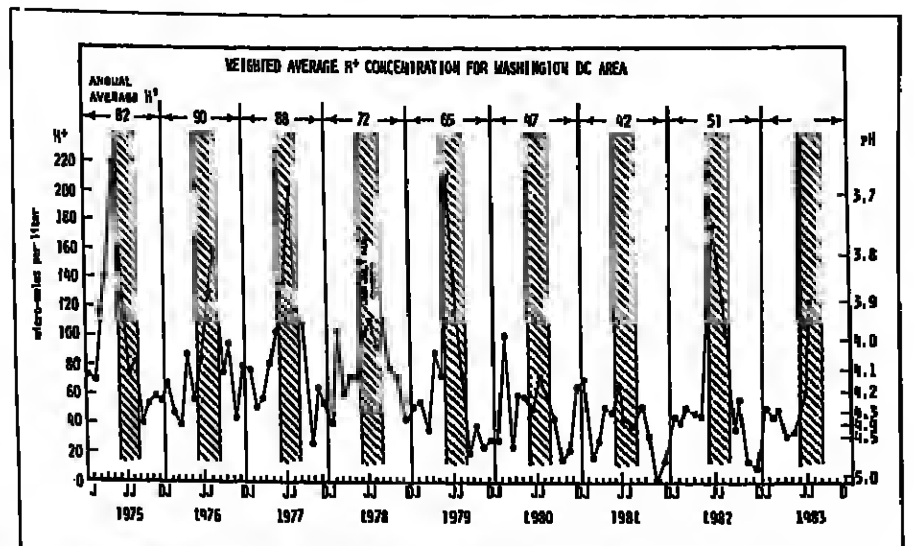


Fig. 1. The monthly concentration of hydrogen ions (left scale) and pH (right scale) in precipitation at about six surburban locations in the Washington, D.C., region. The numbers at the top represent mean annual concentrations of hydrogen ions. All values are weighted by the amount of precipitation. The figure shows that there has been a general decrease in the acidity of precipitation near Washington, D.C., since 1975. Other nearby stations measuring precipitation acidity both support and conflict with the Washington trend. New York City and Long Island measurements show a smaller decrease in acidity, a monitoring station at Edgewater, Maryland (only 40 km east of Washington), shows the opposite trend, while sites at Charlottesville, Virginia (about 160 km southwest of Washington), and State College, Pennsylvania (about 225 km northwest of Washington), exhibit very little systematic change since 1975. (Washington, D.C., data courtesy of John M. Miller of NOAA.)

References

Charlson, R. J., and H. Rhode, Factors controlling the acidity of natural rainwater, *Nature, 295*, 683–685, 1982.
Rhode, H., P. Crutzen, and A. Vanderpol, Formation of sulfuric and nitric acid in the atmosphere during long-range transport, *Tellus, 33*, 132–141, 1981.

News

GOES-4 Failure Investigated

The Visual Infrared Spin-Scan Radiometer (VISSR) on board the western Geosynchronous Operational Environmental Satellite (GOES-4), failed at 0445 UT, November 26, 1982, as a series of intense storms descended on the California coast. The VISSR maps the earth and its cloud cover day and night and allows the tracking and forecasting of severe storm systems. This failure of the VISSR on board GOES-4 deprived weather forecasters of an important means of tracking the nighttime progress of life-threatening storms as they moved across the Pacific.

The cause of this critical satellite failure is of great interest to the National Oceanic and Atmospheric Administration (NOAA), operators of the GOES network. A study now in progress should resolve the reason for failure and determine whether solar activity caused it. Figure 1 was prepared at the National Geophysical Data Center in Boulder, Colo., in response to a call for information about the earth's space environment at the time of the GOES-4 failure.

All GOES spacecraft carry a Space Environment Monitor (SEM) instrument package containing an X ray sensor, a three-component magnetometer, and a particle detector. Together these instruments provide continuous monitoring of the space environment at the satellite's altitude. SEM data from selected satellites are received and processed for archiving at the Space Environment Laboratory in Boulder. When GOES-4 failed at 135°W longitude, the reference satellite for SEM archival purposes was GOES-2, located at 108°W longitude. The proximity of the two satellites suggested that their local environments were similar; and selected data from representative GOES-2 channels were reproduced for November 26–26, 1982.

The top frame of Figure 1 shows the prominent X4.6 solar flare reported by the Space Environment Services Center at 0229 UT. Owing to the intensity of the flare and the history of its associated sunspot region, forecasters at that center immediately posted a proton event warning.

Close inspection of the middle frame shows that indeed the fast, high energy protons in the 110–500 MeV range began arriving at the satellites approximately 45 minutes before failure, with slower protons arriving in quantity a few minutes after failure. Counts of electrons trapped at geostationary altitude, 6.67 earth radii, often show a quiet-time daily variation, a variation that produces lower electron counts in the UT morning than in the UT evening. The electron curve does not drop to quiet-time values on the morning of November 26, indicating the satellite environment contained a significant electron flux at the time GOES-4 failed. Lacking spectral information for electrons, however, we can give no detailed interpretation of their importance.

The magnetometer's three field components are defined as follows: H_p is parallel to the satellite spin axis and is perpendicular to the satellite's orbital plane; H_e lies parallel to the satellite-earth line and points earthward; H_n is perpendicular to both H_p and H_e and points westward. No magnetic storm activity is indicated when GOES-4 failed. Note, however, the correlation between the H_p curve and the electron curve.

This display of the SEM data does not determine the cause of the GOES-4 failure. It does nevertheless raise the question of solar activity as a contributing factor. According to NASA Headquarters, there are currently 86 surveillance and communications satellites in geostationary orbit, representing a U.S. investment in the tens of billions of dollars. An investment of this size will eventually stir renewed interest in Solar-Terrestrial relationships.

Space environment data from the GOES

News (cont. on p. 954)

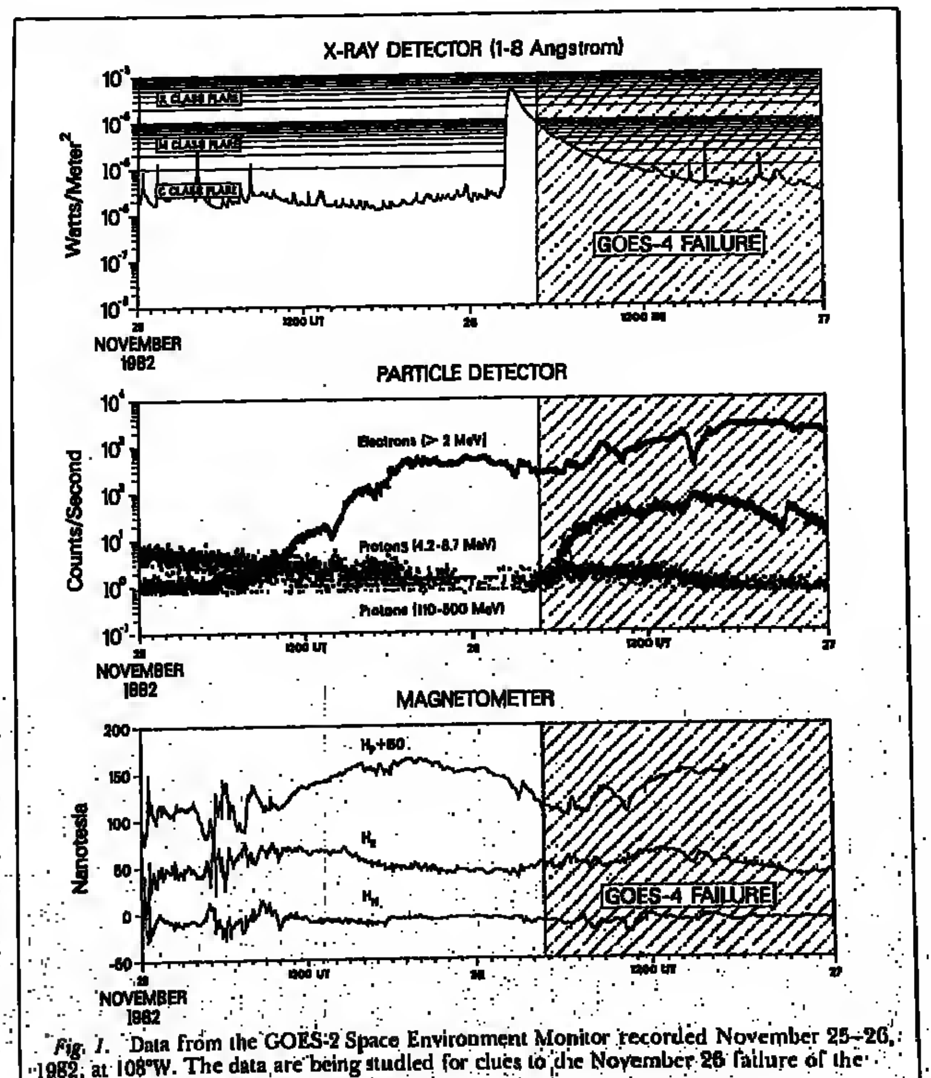


Fig. 1. Data from the GOES-2 Space Environment Monitor recorded November 25–26, 1982, at 108°W. The data are being studied for clues to the November 26 failure of the GOES-4 satellite, at 135°W.

News *(cont. from p. 953)*

system have been archived continuously since July 1974 and are available for sale through the Solar-Terrestrial Physics Division of the National Geophysical Data Center—an organization known internationally as World Data Center A for Solar-Terrestrial Physics. Inquiries should be addressed to the National Geophysical Data Center, NOAA Code E/GC2, 325 Broadway, Boulder, CO 80303 (telephone 303-497-6136).

This news item was contributed by Daniel C. Wilkinson, *who is with the National Geophysical Data Center, Boulder, CO 80303.*

Future Natural Gas Supplies

Despite recent optimism about the outlook for the future supply of domestic conventional natural gas, the Congressional Office of Technology Assessment (OTA) finds insufficient evidence to clearly justify either an optimistic or a pessimistic view. In a technical memorandum entitled "U.S. Natural Gas Availability: Conventional Gas Supply Through the Year 2000," released recently by Rep. Philip R. Sharp (D-Ind.), chairman of the Subcommittee on Fossil and Synthetic Fuels of the Committee on Energy and Commerce, OTA concluded that substantial technical uncertainties prevented a reliable estimation of the likely natural gas production rates for later in this century. Even ignoring the potential for significant changes in gas prices and technology, OTA estimated that conventional gas production by the lower 48 states in the year 2000 could range from 9 to 19 trillion cubic feet (TCF) (0.25 to 0.53 trillion cubic meters), compared to 1982 production of 17.5 TCF. Similarly, production in the year 1990 could range from 13 to 20 TCF.

OTA's wide range of projections for plausible levels of conventional gas production in the lower 48 states in the year 2000 contrasts sharply with the relatively narrow range shown in publicly available forecasts. OTA examined 20 separate gas supply forecasts from oil companies, private institutions and individuals, and government agencies. Thirteen of the 14 forecasts that project a production level for the year 2000 fall within 11 to 15 TCF. According to OTA, this high level of agreement for a production rate two decades from now is made all the more unusual by the probability of substantive differences in the baseline assumptions used by various forecasters.

It was determined that current proved reserves in the lower 48 states will supply only a few TCF per year of production by the year 2000. All other domestic production must come from gas which has not yet been identified by drilling. OTA found no convincing basis for the argument that the lower 48 states have been so intensively explored, and their geology has become so well understood, that a consensus can be reached about the size of the gas resources. According to OTA, plausible estimates for the remaining conventional natural gas in the lower 48 that is recoverable under present and easily foreseeable technological and economic conditions can range from 400 to 900 TCF. This range varies from a level that would seriously constrain gas production by the year 2000 to a level that might allow production to continue at current levels for the remainder of this century.

It is unclear whether the recent surge in the rate of additions to proved gas reserves (for example, 1981 reserve additions were over 20 TCF compared to an average of about 10 TCF per year for 1969–1977) is substantial. Consequently, the range of plausible annual reserve additions is wide even for the near future; OTA estimates that for the lower 48 states for 1986 and beyond the range is from 7–8 TCF to 16–17 TCF, assuming that the current excess of gas production capacity ceases and market conditions improve. The rate at which gas can be withdrawn from proved reserves—the R/P (reserves to production) ratio—may range from 7.0 to 9.5 in the lower 48 by the year 2000, adding additional uncertainty to projections of future production potential. The R/P in 1981 was 9.0, the result of a long and relatively steady decline from a level of 30 in 1946.—*PMB*

Survey of Foreign Graduate Students

In the 1983 American Institute of Physics (AIP) Graduate Student Survey, the issue of foreign versus national students in U.S. graduate programs was explored. In the past decade, the number of entering graduate students from foreign nations in American universities has risen from about 600 to about 1100, an increase from 23% in 1973 to 40% in 1983 of all entering physics graduate students in the United States. There are more than 10,000 graduate students in physics in the United States

The benefits, or lack thereof, of having foreign graduate students raises a number of philosophical points. Like all students, foreign students learn from academic programs; but at high competitive levels, they contribute as well. The essence of growth in any academic program is described by the creativity supplied by ever incoming students. In an academically competitive system the question of foreign students displacing U.S. students in graduate programs has no definition. On the other hand, what about the graduate job market after graduation? Some would point to the return of foreign graduates to their homeland as an example of U.S. education efforts not benefitting U.S. society, at least directly. Others worry about foreign graduates flooding the U.S. job market.

What the AIP Graduate Student Survey indicates is that many foreign graduates in physics did not compete for jobs in the United States this year and thus did not create problems during this year's declining job market. Although noncitizens amounted to over 30% of the total graduate student population; they took only 14% of the jobs in a market in which 52% of the Ph.D.'s had two or more job offers.—*PMB*

Space Science Reference Books

The National Aeronautic and Space Administration's (NASA) Marshall Space Flight Center has recently produced a two-volume reference detailing a wide range of information about the planets, their atmospheres, and their energy fields. Originally prepared by Marshall's Atmospheric Sciences Division as a guide for designing space vehicles, the report was 2 years in the making. It is now available to anyone who wants a handy reference on the current state of knowledge about the sun, planets, and smaller bodies of the solar system.

Entitled "Space and Planetary Environment Criteria Guidelines for Use in Space Vehicle Development, 1982 Revision," the two volumes each have fewer than 200 pages. Volume 1 treats the sun, terrestrial space, the moon, Mercury, Venus, and Mars in individual chapters. Volume 2 covers Jupiter, Jupiter's satellites, Saturn, Uranus, Neptune, Pluto, asteroids, comets, and interplanetary dust. Crammed with numbers, tables, and figures, the two volumes provide a wide range of data, such as the total energy flux of the sun and the mass density of interplanetary dust.

The chapters on the moon and on each planet are subdivided into sections on dynamic properties, physical data such as gravitational and magnetic fields, planetary interiors, surface features, and, when applicable, atmospheres, ionospheres, magnetospheres, and satellites. Here the reader can find up-to-date figures for the composition of Neptune's atmosphere, wind speeds on Venus, the strength of Mercury's magnetic field, or the radius of Pluto's moon Charon. A chapter on the satellites of Jupiter includes data culled from the Voyager missions, including information on several moons discovered by Voyager and on the planet's thin ring system.

In the chapter on terrestrial space there are data on such phenomena as meteoroids and charged particles in the atmosphere, as well as information on how to determine the charge around a spacecraft in earth orbit. This report covers only the natural environment at altitudes greater than 90 km above the earth's surface—another NASA document entitled "Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development" covers the lower atmosphere.

Chapters on comets, on asteroids, and on interplanetary dust clouds include discussions of the distribution and origin of these smaller residents of the solar system. In addition to the data and tables, each chapter also includes an extensive list of references for further reading. Copies of the two-volume document are available upon request to William W. Vaughan, Chief, Atmospheric Sciences Division, ED41, Systems Dynamics Laboratory, NASA Marshall Space Flight Center, Huntsville, Alabama, 35812.

University Contract Research Guidelines

Concerns have been raised in the past few years over the increasing reliance of universities on contracts with outside agencies, public and private. These concerns have been the subject of meetings by the National Commission on Research, the Pajaro Dunes conference of university presidents and corporation executives, the Association of American Universities, and the Association of American University Professors, among others.

The American Civil Liberties Union (ACLU) recently revised its "Policy #64: The University and Contract Research," to address these issues in a way that "will help [university] administration and faculty act so that [their] relationship with government agencies or private industry will in no way violate the professional freedoms which have contributed so much to the status of American higher education." The ACLU has followed the issue, it says, "because of our determination that contractual relationships proceed within a framework that protects fundamental academic freedoms." The ALCU guidelines, dated October 28, 1983, are as follows:

Policy Statement of American Civil Liberties Union on University and Contract Research With Emphasis on Growing Ties Between Corporations and Academic Institutions

Free and open inquiry and unhindered circulation of ideas are fundamental aspects of academic freedom. Externally funded and controlled research may divert the basic interest of the university as a free and open academic community and hence should be curtailed as an intrusion into academic freedom. Contractual research relationships between nonacademic external groups and the university may or may not benefit both parties and society at large. However, generally because of the proprietary interests of nonacademic external groups on the one hand, and on the other the university's need for money and commitment to the widest possible dissemination of knowledge, the potential hazards of these relationships to academic freedom must be recognized. Among the hazards are undue external direction of university-based research, intrusion into the governance of the university and excessive inhibitions on open access to research, on the communication of research findings and on the investigator's time and priorities, claims that may conflict with his/her teaching obligations.

Therefore, to protect the values of academic freedom, the following guidelines should be observed whenever universities enter into contractual research relationships:

Guideline 1 Universities and/or their constituent schools or departments should not accept grants or enter into agreements for the support of instruction or research, which confer upon an external party the power to censor or delay or exercise effective control over either the contents of instruction or the dissemination of results and conclusions arising from instruction or research. Publication of research findings may not be indefinitely delayed, but may, however, be temporarily delayed in order to protect patent rights or permit the research sponsor to review the proposed publication for the sole purpose of identifying proprietary information furnished by and belonging to the sponsor.

Guideline 2 Universities should enter no contract and accept no grant that requires the loyalty or security clearance of any person associated with the project.

Guideline 3 Evaluation of faculty for degree, appointment, tenure, and promotion should remain the exclusive province of the university, and any research not open to critical, professional judgment should not be used as a basis for evaluation.

Guideline 4 In evaluating proposed research projects, the evaluating authority should judge each proposal solely on the basis of the work's merit. The researcher must retain the freedom to choose the subject of his or her inquiry. The individual faculty member should not be subject to institutional or external coercion to accept or not accept a particular research project.

Guideline 5 Universities should not allow their relationships with nonacademic external groups to skew their teaching, research, and public service missions.

Guideline 6 Universities should publicly disclose all forms of research relationships that may be entered into with external entities and all sponsorship or funding by such entities of faculty conferences and workshops.

Guideline 7 While these guidelines should be binding on the university as a corporate entity and on its constituent schools or departments, faculty members should judge the validity and propriety of any arrangements they may enter with an outside agency in their capacity as individuals. They should be aware that when they have a managerial position or equity in a corporation, a threat to academic freedom may arise from a possible conflict of interest in the guidance of graduate students' work, from the selection and publication of research projects, and from proprietary or patent rights in the products of research. The prime responsibility must be to the university's teaching, research, and public service mission.

Books

Our Modern Stone Age

Robert L. Bates and Julia A. Jackson, William Kaufmann, Inc., Los Altos, Calif., vii + 132 pp., 1982, $18.95.

Reviewed by W. D. Lowry

Unlike most books dealing with industrial minerals and rocks, *Our Modern Stone Age* is a pleasure to read. Within a matter of several hours, one can get an excellent introduction to nonmetallic mineral resources and industries exclusive of the mineral fuels. The book is very well written and well illustrated with photographs and drawings; although pitched for the intelligent layman, it is in no way dull reading for even a well-versed economic geologist. Nearly every geologist, mining engineer, mineral economist, planner, and politician will find points of interest in this book.

The introductory chapter emphasizes the role and importance of the industry as a whole and also considers energy requirements and environmental matters. Chapter 2 discusses modern modes of transporting various nonmetallic minerals, and chapter 3 is a particularly well handled discussion of beneficiation processes used in upgrading specific deposits of gypsum, asbestos, feldspar, and beach sands rich in heavy minerals.

The chapter devoted to naturally refined, pure minerals deals with Ottawa silica sand, the Columbus (Ohio) Limestone, Gulf Coast and Salina Basin salt deposits, and California diatomite. The chapter dealing with five chemical minerals includes a discussion of Carlsbad (New Mexico) and Saskatchewan potash deposits, Wyoming trona, and California borax. Another chapter concerns the lightweight aggregates perlite and vermiculite; the use of barite and Western bentonite in drilling mud; the increasing consumption of kaolin, especially in the paper industry; and the importance of graphite and industrial diamonds. Another chapter deals with mineral ingredients used in the manufacture of glass, refractories, and paint.

One of the most interesting chapters is entitled Two Industries with Problems. One of these industries is the extremely important Florida phosphate industry with several serious environmental concerns, and the other involves the production and use of asbestos. Of particular interest to planners and politicians is the chapter called Blast It Out and Break It Up (But Not In My Neighborhood). One case cited is that of a sand and gravel producer on Long Island who was "zoned out of business." On the other hand, a cooperative project between Montclair State College in New Jersey and a nearby producer of crushed "traprock" resulted in the conversion of steep, basaltic terrane into a much-needed, 8.5-hectare site of graded level ground. The final chapter is an outlook for nonmetallic mineral production in the 1980's. Appendices include a list of recent books and papers for further reading, a list of sources of pertinent state publications, and a list of historic mines and quarries and modern mining operations.

Had such a book as *Our Modern Stone Age* been available, my former students in economic geology would not only have found it valuable supplemental reading but also an enjoyable assignment.

W. D. Lowry is with the Department of Geological Sciences, Virginia Polytechnic Institute & State University, Blacksburg, VA 24061.

Irrigation Economics in Poor Countries, Illustrated by the Usangu Plains of Tanzania

Arthur Hazlewood and Ian Livingstone, Pergamon, New York, viii + 144 pp., 1982, $25.

Reviewed by Duncan A. Harkin

This little book of 144 pages could not possibly touch on all of the economic issues concerning irrigation, but the few it does develop make *Irrigation Economics in Poor Countries* worthwhile reading for even those long immersed in the subject as well as for newcomers. It is particularly good in developing the distinctions among run-of-the-river irrigation, storage to even-out seasonal variations in flow, and storage to even-out annual variations. This subject is seldom explored in recent literature on irrigation economics. The authors conclude for their specific study area that storage from year to year is much too costly relative to its benefits to be worthwhile. This conclusion leads one to question whether the same would hold true in many other areas.

The book is composed of four chapters on the economics of irrigation as its principles were found to apply to their study area in Tanzania, followed by five chapters that describe the study area and the developmental context in which the potential irrigation development is set. As such these latter chapters develop some of the nuances of applying the economic models introduced in the first four chapters.

The first chapter shows that in a climate characterized by wet and dry seasons and their resultant irregular river flows, the irrigable area in run-of-the-river irrigation is limited by the low-flow period during the growing season. The authors develop the irrigable area for the Usangu Plains under the assumption of large, mechanized farming operations that have equipment that can plow the ground before the rainy season begins and thereby get an early crop of rice. This becomes important in the second chapter in which the authors develop the demand for irrigation water under two distinctly different types of farms: small peasant producers and the large mechanized farms.

Because the peasant producers do not have mechanized plows they must await the beginning of the rainy season to till the paddies with hand and animal methods. As a result of this difference in timing of farm operations the water demands of the large, mechanized farms and the peasant producers in this specific setting are largely complementary rather than competitive. Chapter 2 uses a linear programming model to develop the optimal mix of mechanized farms and peasant producers and the irrigated area that would apply under that optimal mix.

Chapter 3 introduces the problem of risk that results from variations in flow from the average. It is noted in general that the deficits from the expected average flows can be accommodated by adjustments in the area irrigated (i.e., at the extensive margin), or in the rate of application (the intensive margin), or in some combination of both. A further adaptation to irregularity and unpredictability of flow is, of course, storage, which is discussed in chapter 4.

The authors show a computational method for generating the marginal benefits for an array of different levels of storage and use the linear programming model for optimal mix of peasant-producer and mechanized-farm acreage for each potential level of storage. It is noted, very importantly, that storage partly destroys the complementary relationship between peasant producers and mechanized farms, so that they become increasingly competitive in their demands for the stored irrigation water. These computations include: the engineering factors of water losses due to storage and transmission; the economic considerations of what price to use to value the product; and the problems of exchange rate distortions.

The next four chapters, which discuss the physical and social context of the potential irrigation development, show sensitivity to efficiency versus equity issues and to the practical limitations of capital and human resources. The book ends with a chapter that develops the distinction between technological efficiency and economic efficiency, a point that may seem old to some readers, but perhaps needs to be made again. As part of this argument the authors note that the increasing use of benefit-cost analysis has probably increased general awareness of the frequent divergence between private and social costs and benefits. The authors use the livestock density issue of the Usangu pastoral economy to show that the technical ratio of livestock/land neglects the economic consideration of the number of livestock needed to support subsistence of the herders.

The authors might well have used the problem of livestock density as a prime example of the divergence between individual and social interest and then extended the discussion to one of the most interesting and difficult problems in irrigation economics, groundwater depletion. Groundwater depletion and livestock density are conceptually very similar problems of open-access resources in which use rights are poorly defined, thereby leading to behavior by individuals which depletes the resource, contrary to the interests of the group.

Some other topics of irrigation economics not covered are pricing of irrigation water, large scale versus small scale projects, systems for allocation of water among users (e.g., rotation and continuous flow), investment in new irrigation versus rehabilitation on existing systems, and the effect of land tenure on those who benefit from irrigation. The reader will have to look elsewhere for development of these issues. Yet the book covers a surprising amount of ground in a compact space and concise style.

Duncan A. Harkin is with the Department of Agricultural Economics, University of Wisconsin–Madison, Madison, WI 53706.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For speediest treatment of contributions send three copies of the double-spaced manuscript to one of the editors named below and one copy to AGU.

Editor-in-Chief: A. F. Spilhaus, Jr.; Editors: Marcel Ackerman, Mary P. Anderson, Peter M. Bell (News), Bruce Doe, C. Stewart Gillmor (History), Clyde C. Goad, Arnold L. Gordon, Louis J. Lanzerotti, Robert A. Phinney; Managing Editor: Gregg Forte; Editorial Assistant: Kathleen M. Lafferty; News Writer: Barbara T. Richman; News Assistant: Tony Reichhardt; Production Staff: James M. Hebblethwaite, Dae Sung Kim, Patricia Lichiello, Lisa Lichtenstein, Cynthia T. McManigal.

Officers of the Union

James A. Van Allen, President; Charles L. Drake, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

For advertising information, contact Robin E. Little, advertising coordinator, at 202-462-6903 or toll free at 800-424-2488. Advertising must be informative and consistent with the scientific and educational goals of AGU and is subject to approval by AGU. Advertisers and their agents assume liability for all content of their advertisements and for any claims arising therefrom against the publisher. Offers to advertisers in Eos are subject to all laws and are void where prohibited.

Views expressed in this publication do not necessarily reflect official positions of the American Geophysical Union unless expressly stated.

Subscription price to members is included in annual dues ($20.00 per year). Information on institutional subscriptions is available on request. Second-class postage paid at Washington, D. C., and at additional mailing offices. *Eos, Transactions, American Geophysical Union* (ISSN 0096-3941) is published weekly by

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

Cover. X ray image of the earth's southern auroral oval obtained with the Lockheed X ray imaging spectrometer in the Stimulated Emission of Energetic Particles (SEEP) satellite payload. Superimposed on the map of Antarctica is the spatial distribution of auroral X ray luminosity that is produced by kilovolt electron precipitation. Conspicuous is the auroral oval with intense luminosity near midnight and structured energetic precipitation near dawn. The upper panel displays the energy spectra of X rays observed in the center pixels of the image, while the lower panel shows the simultaneous visible auroral emissions measured by the SEEP photometer. The X ray image is the subject of a paper to be presented at the 1983 AGU Fall Meeting: H. D. Voss et al., SEEP X ray imagery of the earth's aurora (*Eos*, November 8, 1983, p. 792). (Photo courtesy of H. D. Voss, Lockheed Missiles and Space Company, Palo Alto, CA 94304.)

Classified

RATES PER LINE

Positions Wanted: first insertion $1.75, additional insertions $1.50.

Positions Available, Services, Supplies, Courses, and Announcements: first insertion $3.50, additional insertions $2.75.

Student Opportunities: first insertion free, additional insertions $1.50.

There are no discounts or commissions on classified ads. Any type style that is not publisher's choice is charged for at general advertising rates. *Eos* is published weekly on Tuesday. Ads must be received in writing on Monday, 1 week prior to the date of publication.

Replies to ads with box numbers should be addressed to Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D. C. 20009.

For further information, call toll free 800-424-2488 or, in the Washington, D. C., area, 462-6903.

POSITIONS AVAILABLE

National Center for Atmospheric Research/Ph.D. Research Chemist. NCAR's Atmospheric Chemistry and Aeronomy Division seeks experienced Ph.D. researchers with record of sustained productivity in theory and modeling of atmospheric chemistry. Primary interest is in gaseous photochemistry and coupled chemical/meteorological models, but all specialties will be considered along with scientific breadth. Appointment is at Scientist III or Senior Scientist level. Apply with resume to Dr. R. Cicerone, National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307, by December 20, 1983.

Equal Opportunity Employer M/F.

Atmospheric Physicist/Northern Arizona University. Tenure-track assistant professor available January 10, 1984 (or August, 1984) in an eleven-man Physics Department with a joint appointment in Computer Science. Teaching is at the undergraduate level with approximately one-half time devoted to teaching courses related to laboratory applications of computers. Knowledge of FORTRAN at least one assembly language, and fundamental digital logic is essential. Approximately one-half time will be devoted to active research in Physics. Areas of research interest could include radiative transfer, mesoscale dynamics, orographic flows and/or meteorological/environmental instrumentation including remote sensing. Send a complete resume, statement of research interest and professional goals and names of three references to: Dr. Kenneth Odell, Chairperson, Department of Physics, Box 6010, Northern Arizona University, Flagstaff, AZ 86011.

Applications received prior to November 30 will receive full consideration. Ph.D. required. Academic salary range $20,000–25,000.

NAU is an Affirmative Action/Equal Opportunity Employer.

University of Iowa/Faculty Positions. The Department of Physics and Astronomy anticipates two openings for tenure-track assistant professors or visiting faculty at any level in August 1984. In exceptional cases a term or tenured appointment at the associate professor or professor level will be considered. Preference for one position will be given to an experimentalist in intermediate or high energy physics. Current research interests in the department are radio and optical astronomy and the following specialities in physics: atomic, condensed matter, elementary particles, laser, nuclear, plasma, and space physics. Faculty duties include undergraduate and graduate teaching, guidance of research students and personal research. Interested persons should submit a resume and a statement of research interests and arrange for three letters of recommendation to be sent to Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity/affirmative action employer.

Oregon State University/Fisheries Oceanography. Applications are invited for a 12-month, tenure-track position as Assistant Professor in the College of Oceanography with a joint appointment in the Department of Fisheries and Wildlife. Applicant must have demonstrated ability to conduct independent research and obtain research funding in the areas of ecology of marine fishes or nekton. Workers with interests in ecology, fisheries oceanography, or population biology of nekton will be considered. Applicant must have Ph.D. Postdoctoral experience desirable.

The appointee will be expected to teach courses in fisheries oceanography or in the ecology of marine nekton, to supervise graduate students, and to develop a program of grant-funded research. Salary $27,000–35,000, negotiable. Application materials, including a brief statement of research plans and the names of three references, should be submitted not later than 31 January 1984 to: G. Ross Heath, Dean, College of Oceanography, Oregon State University, Corvallis, Oregon 97331.

Affirmative Action/Equal Opportunity employer.

Boston University/Faculty Position. The Astronomy Department at Boston University expects to have a faculty position available beginning either January or September 1984, extending at least through the 1984/85 academic year. Applicants are sought who have teaching experience and who have a proven research record as evidenced by publications and recommendations. Research programs in the department include ionospheric and magnetospheric physics, galactic astronomy, and extragalactic and high energy astrophysics. Applicants with research programs in any of these areas will be considered; however, preference will be given to those with experimental or observational interests.

Equal consideration will be given to individuals wishing to start in January or September 1984. Depending on the future availability of funds, this position may be converted to a permanent line leading to eventual tenure.

Please send a curriculum vitae, names of three persons who can provide an evaluation of your teaching and research and a brief statement of current research interests to:

Kenneth Janes, Chairman
Astronomy Department
Boston University
725 Commonwealth Avenue
Boston, MA 02215
(617) 353-2627

Boston University is an Equal Opportunity/Affirmative Action Employer.

University of California, San Diego/Assistant Research Chemist. The Institute of Marine Resources at the Scripps Institution of Oceanography, University of California San Diego, anticipates an opening for an ASSISTANT RESEARCH CHEMIST (salary range: $22,900–$28,800) in the Food Chain Research Group. The primary responsibility of the position is to carry out fundamental research in marine organic chemistry in association with other IMR oceanographers.

Applicants must have (i) a Ph.D. in organic chemistry, marine chemistry or chemical oceanography and at least two years of post-doctoral experience in marine chemistry; (ii) an ability to carry out independent research in the ocean as demonstrated by an active publication record in refereed journals; and (iii) experience in work at sea with modern sampling and analytical methods.

Send resume and names of three referees by March 1, 1984, to:

Dr. Fred N. Spiess, Director
Institute of Marine Resources, A-028
Scripps Institution of Oceanography
University of California San Diego
La Jolla, California 92093

The University of California San Diego is an equal opportunity/affirmative action employer.

Geophysicist, Tectonophysicist/Georgia Tech. The School of Geophysical Sciences at Georgia Tech invites applications for a faculty appointment in Earth Sciences. Applicants must have an outstanding research potential demonstrated by several years of postdoctoral experience or a well-established research record, and experience in securing research funding. Although no field of specialization is excluded, preference will be given to candidates with a background in geophysics/tectonophysics.

The School of Geophysical Sciences has an expanding and active research program in many areas of Earth and Atmospheric Sciences. The School has 23 full-time faculty members and over 50 graduate students.

Applications including resumes, phone numbers, and the names and addresses of at least three references should be submitted to Jean-Claude Mareschal, Chairman, Geophysics Search Committee, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30332.

The Georgia Institute of Technology is a unit of the university system of the State of Georgia.

Georgia Tech is an affirmative action/equal opportunity employer.

RESEARCH FACULTY POSITION

DEPARTMENT OF OCEANOGRAPHY
NAVAL POSTGRADUATE SCHOOL

An (adjunct) research faculty position in physical/dynamical oceanography is immediately available; it is expected to continue for several years. A PhD in physical oceanography, meteorology, geophysical fluid dynamics, applied mathematics, physics or engineering is required. The position is dedicated to a program, in synoptic/mesoscale ocean prediction over an open domain, called OPTOMA (Ocean Prediction Through Observations, Modeling, and Analysis). OPTOMA is a joint NPS/Harvard program, sponsored by ONR, which has been in progress for a year-and-a-half. A series of ocean prediction experiments in the eddy field of the California Current System is planned over the next several years. The scientific responsibilities of the position involve: (1) running simulations and prediction experiments with, and evolving, the Harvard statistical-dynamical (a quasi-geostrophic model interacting with a statistical objective analysis) model, (2) participating in seagoing, real-time ocean prediction experiments, often as a chief scientist, (3) conducting data analysis studies, and (4) developing leadership in the physical interpretation of synoptic/mesoscale processes. Hence, a strong background in ocean dynamics and an active involvement in numerical modeling are required. In summary, this is an important scientific opportunity for someone interested in combining synoptic work at sea with theory and numerical modeling.

Assets of the Department include a research vessel with ready access to an exciting region of the ocean, free access to an IBM 333 with excellent graphics capabilities, and proximity to the Fleet Numerical Oceanography Center and the Naval Environmental Prediction Research Facility. Links exist to NORDA, the Naval Oceanographic Office, other Navy labs, and NOAA activities, as well as other academic institutions. Altogether, there are over 100 practicing physical oceanographers and meteorologists in the Monterey area. Finally, the Monterey area has spectacular climate and scenery.

We will welcome applications on a continuing basis. However, the initial closing date will be *9 December 1983*. Send a curriculum vitae; statement of professional interests; and names, addresses, and telephone numbers of at least three references to:

Professor Christopher N. K. Mooers
Chairman, Oceanography Department, Code 68Mr
Naval Postgraduate School Monterey, CA 93943
Telephone: (408) 646-2673

The Naval Postgraduate School is an Affirmative Action/Equal Opportunity Employer.

Physical Oceanographer/Oregon State University. Assistant or Associate Professor, depending on experience. Applicants may be observationalists or theoreticians but must have a Ph.D. in the physical sciences, have demonstrated the ability to conduct independent high-quality research and be expected to obtain research funding. Duties include teaching and supervision of graduate students. Interested candidates should submit a resume and names of three references by 1 February 1984 to: G. Ross Heath, Dean, College of Oceanography, Oregon State University, Corvallis, OR 97331.

OSU is an Affirmative Action/Equal Opportunity employer, complying with Section 504 of the Rehabilitation Act of 1973.

Assistant Professor/Yale University. Tenure-track position which will contribute to a group of natural and social scientists with interests in the analysis of public and private natural resource policy. The successful candidate will have a Ph.D. with a strong emphasis on management science as well as education or experience in forestry, water resources, or a closely related field in natural resources.

To apply, candidates should send transcripts, curriculum vitae, a letter of application explaining interest and skills, and should arrange to have three letters of recommendation sent by January 15, 1984 to Clark S. Binkley, Search Committee Chair, School of Forestry & Environmental Studies, Yale University, 205 Prospect Street, New Haven, CT 06511.

Yale University is and equal opportunity/affirmative action employer.

THE AUSTRALIAN NATIONAL UNIVERSITY. Invites applications from suitably qualified persons for appointment to three tenurable/tenured positions and four non-tenure positions in the Research School of Earth Sciences:

Senior Fellow/Professorial Fellow in Environmental Geochemistry. ...

Senior Fellow/Professorial Fellow in Seismology. ...

Fellow/Senior Fellow in Geophysical Fluid Dynamics. ...

Postdoctoral Fellow/Research Fellow/Senior Research Fellow in Seismology. ...

Postdoctoral Fellow/Research Fellow in Earth Physics. ...

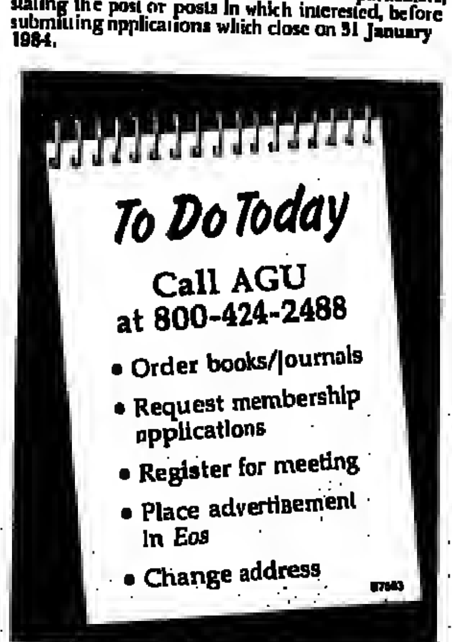
Research Fellow in Geochronology and Isotope Geochemistry. ...

Research Fellow in Petrochemistry. ...

Salary in accordance with qualifications and experience within the ranges: Professor $52063 p.a.; Professorial Fellow $45318 p.a.; Senior Fellow $36585-$42043 p.a.; Fellow $27272-$35537 p.a.; Senior Research Fellow $32379-$38980 p.a.; Research Fellow $25394-$30794 p.a.; Postdoctoral Fellow Grade I (at fixed point) $20164-$23100 p.a. Current exchange rates: $A1 = $US0.91 = UK60P = $Can1.12.

Appointment as Postdoctoral Fellow is normally for not less than one year no more than two years but may in certain cases be extended to three years. Research Fellow/Senior Research Fellow appointments are normally for up to three years with the possibility of extension to four or five years. Fellow/Senior Fellow appointments are for an initial period of five years with the possibility, following review, of reappointment to retiring age. Appointment as Professorial Fellow/Professor is to retiring age (65) with the option of retirement after the age of 55.

Grants are provided towards travel and removal; assistance with housing; superannuation. The University reserves the right not to make an appointment or to make an appointment by invitation at any time. Applicants should write to The Registrar, The Australian National University, G.P.O. Box 4, Canberra, A.C.T., Australia, for further particulars, stating the post or posts in which interested, before submitting applications which close on 31 January 1984.



Staff Scientists/Systems Analysts. Research and Data Systems, Inc. has openings available for Staff Scientists, Systems Analysts and Programmer/Analysts to work in areas involved in the processing and application of data from satellite based remote sensing systems. Particular needs involve the analysis and processing of Earth Radiation Budget, Microwave, AVHRR and LANDSAT data. Needs also exist in the areas of interactive image graphics, software engineering, realtime processing and satellite data communications. Successful candidates will have an advanced degree in meteorology, physics, engineering, mathematics, or computer sciences. Hardware background should include IBM, DEC, CYBER or HP-1000 equipment. Send resume in confidence to:

Research and Data Systems, Inc.
10300 Greenbelt Road, Suite 206
Lanham, Maryland 20706
Telephone: (301) 390-6100

Duke University/Tenure-Track Position. The Department of Geology is seeking applicants for a tenure-track position in the general field of Paleontology/Sedimentary Geology. Rank for the position is at the Assistant Professor level and the PhD is required. Undergraduate teaching responsibilities include Historical Geology and Invertebrate Paleontology. The appointee will be expected to develop graduate level courses, to initiate a research program, and to direct graduate students at both the MS and PhD levels. An opportunity exists to offer courses and conduct research at the Duke Marine Laboratory. The position is to be filled by September, 1984 with a closing date of December 31, 1983 for the acceptance of applications.

Interested applicants should send a resume and the names and addresses of three references to Chairman, Department of Geology, Duke University, Box 3729 College Station, Durham, North Carolina 27708.

Duke University is an equal opportunity/affirmative action employer.

Hydrogeologist/University of Illinois at Urbana-Champaign. The Department of Geology has reinstituted its search for a hydrogeologist to fill a permanent, tenure-track faculty position. The appointment will be at the Assistant Professor level. Salary is negotiable. A Ph.D. is required. Starting date will be August 21, 1984. The successful candidate will have a demonstrated background in one or more of the following areas of hydrogeology: basin analysis, flow in porous media, or chemical interactions between groundwater and rock and will be expected to teach one or more graduate courses in hydrogeology, to participate in our undergraduate instructional program, and to maintain and enhance our existing strong research program in hydrogeology. For equal consideration, application including the names of three referees should be sent by February 1, 1984 to:

Professor S. James Kirkpatrick
Department of Geology
245 Natural History Building
1301 West Green Street
Urbana, IL 61801
Ph. (217) 333-3542

The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

Meteorologist/The City College of The City University of New York. The Department of Earth and Planetary Sciences invites applications for an anticipated opening in meteorology. The appointment will start September, 1984. Applicants should have completed the Ph.D. by the time of appointment and have a strong background in synoptic meteorology and computer applications. In addition, the individual should have an interest in atmospheric chemistry or pollution as applied to urban areas, or physical oceanography. The person hired will be required to teach courses in meteorology, and possibly physical oceanography as well as develop and maintain an active research program. Participation in the C.U.N.Y. Ph.D. Program in Earth and Environmental Sciences is anticipated. Rank and salary will be commensurate with experience. Send resume, transcripts and three letters of reference by November 30, 1983 to Professor Dennis Weiss, Chairman, Department of Earth and Planetary Sciences, the City College, 138 Street and Convent Avenue, New York, N.Y. 10031.

The City College of the City University of New York is an equal opportunity affirmative action employer.

Geophysicist Tenure-Track Appointment/Department of Geology, University of Toledo. The position is effective September 1, 1984. Individuals with strong backgrounds in exploration geophysics—applied geophysics are of primary interest although other specializations will be considered. The Ph.D. is required as well as a strong commitment to effective teaching and research. The department has modern facilities and offers B.S., B.A., and M.S. degrees to approximately 60 undergraduate and 50 graduate students. The faculty consists of eight full time and five adjunct professors actively involved in a wide range of research pursuits. Interested persons should submit a letter of application, resume, transcripts, and three letters of recommendation to: Stuart L. Dean, Chairman of Search Committee, Department of Geology, University of Toledo, Toledo, Ohio 43606, phone (419) 537-2246 or (419) 527-2009.

University of Toledo is an equal opportunity/affirmative action employer.

Massachusetts Institute of Technology/Principal Research Scientist. A Principal Research Scientist position is available in the Department of Earth, Atmospheric, and Planetary Sciences at M.I.T. Applicants must have a Ph.D. in planetary science and possess a thorough knowledge of the chemical thermodynamics of multicomponent gas and mineral systems and its application to important planetary and meteoritical problems. In addition, applicants must have a recognized record of accomplishment in planetary science demonstrated by an appropriate research program in the field which may include the supervision of graduate students.

This is a permanent research staff position. Applicants should submit resume, publication list, and names of three references to:

William F. Brace
c/o Anne Starr
Personnel Office, E19-238
M.I.T.
Cambridge, MA 02139

M.I.T.'s commitment to affirmative action encourages applications from all candidates without regard to race or sex.

Arizona State University/Geochemistry Research Specialist. To operate and modify automated SEM facility for aerosol particle analysis in atmospheric geochemistry research. Software development and SEM/EDS experience necessary. Ph.D. optional. Competitive salary. Send resume, statement of experience to personnel, Arizona State University, Tempe, Arizona 85287 and names of three references to Dr. P.R. Buseck, Depts. of Geology and Chemistry.

ASU is an EO/AA employer.

McMaster University/Assistant Professor. Applications are invited for an appointment at the assistant professor level initially for two years. Ph.D. must be completed or near completion. Research specialization is required in physical geography. Undergraduate teaching responsibilities will include air photo interpretation and other aspects of remote sensing and mapping. Salary according to scale. Apply with full curriculum vitae and the names of three referees to Dr. M.J. Webber, Department of Geography, McMaster University, Hamilton, Ontario, Canada, L8S 4K1 before February 15, 1984.

In accordance with Canadian Immigration requirements priority will be given to Canadian citizens and permanent residents of Canada.

Igneous/Metamorphic Petrologist or Structural Geologist/Hobart and William Smith Colleges. The Department of Geoscience of these private, coordinate, liberal arts colleges seeks applicants for a full-time, tenure-track position for September, 1984. We need a field-oriented, igneous or metamorphic petrologist or structural geologist, a person committed to excellence in teaching and to stimulation of undergraduate research. Ph.D. required and teaching experience desirable. Teaching includes introductory courses, mineralogy, petrology and structure plus participation in the Colleges' general curriculum. Research encouraged and supported. Submit Vitae and three letters of recommendation to: Donald L. Woodrow, Department of Geoscience, Hobart and William Smith Colleges, Geneva, NY 14456. Applications from women and members of minority groups encouraged.

Hobart and William Smith Colleges are equal opportunity/affirmative action employers.

Chair/Northern Illinois University/Chair. Applications are invited for the position of Chair of the Department of Geology. We seek candidates who have an established commitment to research and who are interested in the challenge of leading a young and growing department which has just recently established a Ph.D. program. The department is committed to the further development of a strong Ph.D. program and is looking for candidates who would share that commitment. We seek the strongest possible candidates without regard to specialty; however, candidates from the areas of hydrogeology, hydrogeochemistry or geophysics are particularly encouraged to apply.

Rank and salary for the position are negotiable. Send resume and statement of interest to Dr. M.P. Weiss, Chair, Search Committee, Department of Geology, Northern Illinois University, DeKalb, IL 60115.

Northern Illinois University is an affirmative action/equal opportunity employer.

Oceanographic Microbiologist/Oregon State University. The College of Oceanography at Oregon State University has an assistant professorship position open for an oceanographic microbiologist. The appointee will be expected to develop a program of grant-funded research in the area of marine microbiology. Opportunities will be available for teaching of classes and seminars in marine microbiology and biological oceanography and for supervision of graduate students. Candidates should hold a Ph.D. in biological oceanography, microbiology, or related discipline, and have postdoctoral research experience specifically with marine microbes. Salary: $27,000-$35,000, negotiable. Submit resume and names of three references before 15 January 1984 to: Dr. G. Ross Heath, Dean, College of Oceanography, Oregon State University, Corvallis, Oregon 97331.

Affirmative Action/Equal Opportunity employer.

Faculty Position/Massachusetts Institute of Technology. The Department of Earth, Atmospheric, and Planetary Sciences of the Massachusetts Institute of Technology is seeking to appoint a physical oceanographer at the assistant professor level. Candidates will be considered from any area of physical oceanography, but the department is particularly interested in developing its programs (both theoretical and observational) in large-scale, deep-sea, physics. Individual chosen would be expected to carry on a vigorous research program and to teach graduate level courses in physical oceanography. Will be a member of the Center for Meteorology and Physical Oceanography.

Please submit resume, publication list, statement of interests, and names of three references to:

W.F. Brace, Chairman
Dept. of Earth, Atmospheric,
and Planetary Sciences
54-918
MIT
Cambridge, MA 02139

MIT is an affirmative action/equal opportunity employer.

Sedimentary Biogeochemist/University of Hawaii. The Department of Oceanography and Hawaii Institute of Geophysics, University of Hawaii, are searching for a creative marine scientist for a tenure track position at the Assistant or Associate Professor level, with interest in seawater-mineral interactions. Applicants should have talents for investigation of problems involving both organic and inorganic phases.

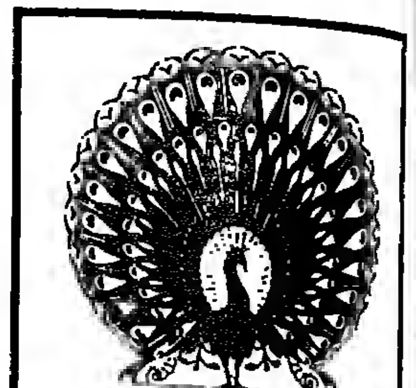
The Department and Institute have a wide range of facilities available including research vessels and fully-equipped environmental chemistry, low-temperature geochemistry, and sedimentologic laboratories, as well as XRD, XRF, SEM, STEM, GC, LC, IR, Raman, microprobe, mass spectrometry and radiochemical instrumentation.

The scientist selected will be expected to develop a research and teaching program and to guide and support graduate students. Applications and names of three referees should be sent to Dr. Keith E. Chave, Department of Oceanography, 1000 Pope Road, University of Hawaii, Honolulu, HI. 96822. Closing date 1 January 1984 for starting date 1 August 1984.

The University of Hawaii is an Equal Opportunity/Affirmative Action Employer.

Colorado School of Mines/Research Fellowship. Research Fellowship in the isotopic geochemistry of extraterrestrial rocks. The study concentrates on nuclear geochemistry and geochronology of Lu-Hf, Sm-Nd, Rb-Sr, and U-Th-Pb systems in meteorites, lunar samples, and relevant terrestrial systems. This is a joint research program with the Colorado School of Mines and the U.S. Geological Survey. The appointee will perform most of the experiments at the USGS Isotope Branch, where up to date facilities are available for isotopic studies. Candidates should have a Ph.D. in geochemistry or planetary science. Experience in mass spectrometry or radio chemistry is desirable. The stipend is $21,000-$25,500 per year depending on experience and tax status. Begins on February 8, 1984 for 1, possibly 2 years. Send resume, two letters of recommendation, and a statement of research interests to: Thomas R. Wildeman, Dept. of Chemistry/Geochemistry, Colorado School of Mines, Golden, Colorado 80401. Phone: (303) 273-3000.

CSM is an equal opportunity/affirmative action employer.



University of California, Riverside/Geology ...

University of Massachusetts, Amherst/Faculty Position in Stratigraphy-Micropaleontology. ...

Massachusetts Institute of Technology/Faculty Openings in Meteorology. ...

Postdoctoral Research Position/University of California, Berkeley. ...

Memorial University of Newfoundland/Tenure-Track Position. ...

Ohio State University/Mineralogist. ...

Texas A&M University/Deputy Department Head. ...

National Center for Atmospheric Research/Visitor Applicants. ...

Princeton University/Faculty Appointment. ...

University of Texas at Austin/Getty Chair. ...

Northern Illinois University/Geophysicist. ...

STUDENT OPPORTUNITIES

University of Miami/Graduate Research Assistantships in Physical Oceanography and Meteorology. ...

Opportunities for Graduate Studies in Atmospheric Sciences/Georgia Institute of Technology. ...

GRADUATE STUDENT NASA TRAINEESHIPS ...

Meetings

Announcements

Oceans 84

The Marine Technology Society and the Institute of Electronics and Electrical Engineers/Oceanic Engineering Society will hold the Oceans 84 Conference and Exhibition in Washington, D. C., September 10–12, 1984. ... "Industry, Government, and Education—Designs for the Future," and the deadline for submitting abstracts is February 6. ...

For more information, or to submit an abstract (no more than 200 words long), contact the Oceans 84 Technical Program Committee, 1730 M Street, N.W., Suite 412, Washington, DC 20036.

Australian Geology

The Geological Society of Australia will hold its Seventh Australian Geological Convention in Sydney, Australia, August 26–31, 1984. ... For more information contact Secretary 7 AGC, P.O. Box 383, North Ryde, NSW, Australia 2113.

Ocean Sciences Meeting

Session Summary, Travel, Housing, Registration

The 1984 Ocean Sciences Meeting of the American Geophysical Union (AGU) will be held January 23–27, 1984, in New Orleans at the Fairmont Hotel. Cosponsoring societies are the American Society of Limnology and Oceanography (ASLO); the Acoustical Society of America (ASA); the American Meteorological Society (AMS); the Marine Technology Society (MTS); and the Institute of Electrical and Electronics Engineers Oceanic Engineering Society (OES). ...

The 1984 Ocean Sciences Meeting is an opportunity to advance the unity of ocean science and engineering in a stimulating and pleasant environment. We hope to see you there!

Registration

Everyone who attends the meeting must register. Preregistration (received by January 6, 1984) saves you time and money; the fee will be refunded to you if AGU receives written notice of cancelation by January 16. Registration for 1 day only is available at one half of the applicable preregistration rates, either in advance or at the meeting. Registration rates are as follows:

	Preregistration	After Jan. 6, 1984
Member	$65	$80
Student member	$32	$47
Retired senior member*	$32	$47
Nonmember	$85	$100
Student nonmember	$39	$54

*Age 65 or over

...

Hotel Accommodations

The meeting will be at the elegant Fairmont Hotel, which is at the edge of the Vieux Carré (French Quarter). ... A block of rooms is being held at the Fairmont Hotel. Room rates are $60 single, $60 double. ... Read the housing application form and mail the completed application directly to the Fairmont Hotel, Reservations, University Place, New Orleans, LA 70140. MAIL EARLY to ensure confirmation. Deadline for reservations is December 23. Please do not write or call AGU for room reservations.

Special Events

An Ice Breaker on Monday evening from 5:30 to 7 P.M. at the Fairmont is the opening social event of the meeting.

On both Tuesday and Thursday evenings a social hour from 6:30 to 8 P.M. has been tentatively scheduled so participants may gather to make plans for evening activities.

There will be a Wednesday luncheon in the Imperial Ballroom from noon to 2 P.M. The luncheon speaker will be announced in a later issue of Eos. Tickets are $12. Purchase

Meetings (cont. on p. 958)

Meetings *(cont. from p. 957)*

your ticket early; there will be only a limited supply at the meeting.

Scientific Sessions

The preliminary program along with the abstracts will be published in the December 27 issue of *Eos*. The final program, with presentation times, will be distributed at the meeting. All scientific sessions will be held at the Fairmont Hotel.

Exhibits

Exhibits of equipment, programs, books, and organizations are planned to run daily from Tuesday, January 24, to Thursday, January 26, 9 A.M. to 4 P.M.

Session Summary

Submarine Vent Systems, Mon AM
Polymode, Mon AM
Microaggregates, Mon AM
Mississippi River, Mon AM
Acoustic Remote Sensing, Mon AM
Nutrients Patterns, Mon AM

Amazon Shelf Dynamics, Mon PM
Boundary Currents, Mon PM

Plankton Spatial Pattern, Mon PM
Trace Metal Interactions, Mon PM
Acoustic Imaging, Mon PM
Basin Physical Oceanography, Mon PM

Marine Geochemistry, Tues AM
Zooplankton Behavior I, Tues AM
El Niño I, Tues AM
Optics and Biology, Tues AM
Arctic I, Tues AM
Short-Term Variability, Tues AM

Benthic Boundary Layer, Tues PM
Zooplankton Behavior II, Tues PM
El Niño II, Tues PM
Chlorophyll, Tues PM
Arctic II, Tues PM
Phytoplankton Biology I, Tues PM

Submarine Canyons I, Wed AM
SAR Surface Signatures, Wed AM
Plankton Productivity I, Wed AM
Gulf Mexico/Caribbean I, Wed AM
Macrophytes and Corals, Wed AM
Upper Ocean Dynamics, Wed AM

Submarine Canyons II, Wed PM
Surface Waves, Wed PM
Plankton Productivity II, Wed PM
Gulf Mexico/Caribbean II, Wed PM

Wetlands, Wed PM
Large Scale Obs. & Heat Transp., Wed PM

Ocean Instrumentation I, Thurs AM
Feeding Ecology, Thurs AM
Warm Core Rings I, Thurs AM
Nitrogen Cycles, Thurs AM
Venezuela Basin I, Thurs AM
OPUS, Thurs AM

Ocean Instrumentation II, Thurs PM
Year Class Fluctuations, Thurs PM
Warm Core Rings II, Thurs PM
Cyanobacteria, Thurs PM
Venezuela Basin II, Thurs PM

Contaminants: Great Lakes I, Thurs PM

Ocean Tracers, Fri AM
Southern Oceans I, Fri AM
Phytoplankton Responses I, Fri AM
Shelf Dynamics I, Fri AM
Forams, Rads and Bacteria, Fri AM
Contaminants: Great Lakes II, Fri AM

Radioactive Disposal, Fri PM
Southern Oceans II, Fri PM
Phytoplankton Responses II, Fri PM
Shelf Dynamics II, Fri PM
Bioluminescence & Zooplankton, Fri PM
Marine Pollutants, Fri PM

American Geophysical Union OCEAN SCIENCES MEETING

January 23-27, 1984

Housing Reservation Form

Please note: Reservation must be received by December 23 to ensure space. All reservations must be guaranteed by enclosing payment for first night's deposit or by including American Express, Carte Blanche, or Diner's Club card number. Cancelations must be received by the hotel before 6 P.M. of the arrival date or the room will be billed for one night and the reservation canceled. All rooms are subject to city room tax.

Please Check Type of Accommodations

☐ Single $60

☐ Double $60

Mail Form Directly to:
Fairmont Hotel
Reservations Dept.
University Place
New Orleans, LA 70140

Arrival Date ____________ AM ______ PM ______

Departure Date ____________ AM ______ PM ______

Names ____________

Address ____________

City ____________ State/Prov ______ Zip ______

Country ____________

Telephone # ____________

Please print or type. List names of both persons if double room.

GAP

Separates

To Order: The order number can be found at the end of each abstract; use all digits when ordering. Only papers with order numbers are available from AGU. *Cost:* $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order. Deposit accounts available.

Send your order to:
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009

Geomagnetism and Paleomagnetism

2360 Time Variations, Paleomagnetism
A DETAILED RECORD OF THE LOWER JARAMILLO POLARITY TRANSITION FROM A SOUTHERN HEMISPHERE DEEP-SEA SEDIMENT CORE
B. M. Clement (Lamont-Doherty Geological Observatory, Palisades, New York, 10964), D. V. Kent

A detailed record of the lower Jaramillo (reversed to normal) polarity transition was obtained from a southern hemisphere, deep-sea sediment core (lat=33.91°S, long=39.97°E). The record consists of over 630 samples taken across 140cm of section. The transition itself is recorded across approximately 70cm and is represented by more than 475 specimens from about 160 levels giving intermediate directions. The transition is identified by a nearly 180° shift from directions in good agreement with a reversed, axial dipole field to those closely aligned with a normal, axial dipole field for the core site latitude. The inclinations shallow gradually early in the reversal and pass through very steep negative values (~80°) late in the transition. The declinations show little appreciable variation until the inclinations have moved through the near vertical, and then slowly approach values in agreement with a normal polarity field. An intensity low accompanies the directional change during which the intensity drops to less than 15% of the maximum values observed in this sample interval. The intensity fluctuation spans a wider interval than the directional change, decreasing prior to any [illegible] change in the directions and then increasing to pre-transition levels [illegible] depth at which the directions have stabilized. The VGP path constructed for this reversal is longitudinally constrained to a certain extent, between 140° and 230° for intermediate VGP latitudes and is roughly centered 120° from the site longitude. This path is therefore a far-sided VGP path in Hoffman's terminology. Assuming a constant sedimentation rate (67m/Ma) through the Jaramillo Subchron, the duration of the transition is estimated to be 11,200 yrs to 4,300 yrs (depending on the criteria) for the directional change, whereas the associated intensity variation occurred over 15,000 to 20,000 years. Considered together with records of the most recent reversal (Matuyama/Brunhes) in light of current transitional field models, this record strongly suggests that the lower Jaramillo transitional field was dominated by different harmonics than the Matuyama/Brunhes transitional field. (Polarity transition)

J. Geophys. Res., Earth, Paper 3B1776

RETURN THIS FORM WITH PAYMENT TO:

Meeting Registration
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

PLEASE PRINT CLEARLY

NAME ON BADGE
|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

AFFILIATION
|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

MAILING ADDRESS ____________

____

____

Telephone # ____________

Days you plan to attend.
Please check appropriate box.
☐ Monday ☐ Wednesday ☐ Friday
☐ Tuesday ☐ Thursday

Members of the cosponsoring societies may register at AGU member rates.
☐ Member AGU ☐ Nonmember
☐ Member Cosponsoring Society
☐ ASLO-American Society of Limnology and Oceanography
☐ ASA-Acoustical Society of America
☐ AMS-American Meteorological Society
☐ MTS-Marine Technology Society
☐ OES-Institute of Electrical and Electronics Engineers Oceanic Engineering Society

Preregistrants
Your receipt will be in your preregistration packet. The registration fee will be refunded if written notice of cancelation is received in the AGU office by January 18. The preliminary program and meeting abstracts will appear in the December 27 issue of *Eos* and will be available at the meeting.

Nonmembers
The difference between member (or student member) registration and nonmember registration may be applied to AGU dues if a completed membership application is received at AGU by April 25, 1984. Current AGU annual dues are: $20 Members; $7 Student Members.

AGU OCEAN SCIENCES MEETING

January 23-27, 1984
New Orleans, Louisiana

REGISTRATION FORM

Deadline for Receipt of Preregistration JANUARY 6, 1984

(Rates applicable only if received by January 6, 1984.)

	More than one day	One day
MEMBER	☐ $65.00	☐ $32.50
STUDENT MEMBER	☐ $32.00	☐ $16.00
NONMEMBER	☐ $85.00	☐ $42.50
STUDENT NONMEMBER	☐ $39.00	☐ $19.50
RETIRED SENIOR MEMBER	☐ $32.00	☐ $16.00
LUNCHEON, WEDNESDAY Jan. 25	☐ $12.00	☐ $12.00

All orders must be accompanied by payment or credit information. Make check payable to AGU.

Total Enclosed $ ____________

Charge to: ☐ American Express ☐ Visa ☐ Master Card

Card Number ____________

Expiration Date ____________

Signature ____________

Office Use
Code ______
Check No. ______

Oceanography

[illegible] J. Geophys. Res., Oceans, Paper 3C1747

4780 Underwater Sound
OCEANIC WINDS MEASURED FROM THE SEAFLOOR
David L. Evans ... University ... O. Randolph ...
[illegible]

Journal of Geophysical Research

Volume 88 Number A12 December 1, 1983

Title	Authors	Page
Differences in the Temporal Variations of Solar UV Flux, 10.7-cm Solar Radio Flux, Sunspot Number, and Ca-K Plage Data Caused by Solar Rotation and Active Region Evolution (Paper 3A1463)	R. F. Donnelly, D. F. Heath, J. L. Lean, and G. J. Rottman	9883
Latitudinal and Field-Aligned Cosmic Ray Gradients 2 to 5 AU: Voyagers 1 and 2 and IMP 8 (Paper 3A1488)	E. C. Roelof, R. B. Decker, and S. M. Krimigis	9889
The Structure of the Heliospheric Current Sheet: 1978-1982 (Paper 3A1464)	J. Todd Hoeksema, John M. Wilcox, and Philip N. Scherrer	9910
The Radial Evolution of a Single Solar Wind Plasma Parcel (Paper 3A1183)	Steven J. Schwartz and Eckart Marsch	9919
The Effects of Coulomb Collisions on Solar Wind Ion Velocity Distributions (Paper 3A1356)	E. Marsch and H. Goldstein	9933
Multiple Spacecraft Observations of Interplanetary Shocks: ISEE Three-Dimensional Plasma Measurements (Paper 3A1366)	C. T. Russell, J. T. Gosling, R. D. Zwickl, and E. J. Smith	9941
Electron Velocity Distributions Near Interplanetary Shocks (Paper 3A1404)	W. C. Feldman, R. C. Anderson, S. J. Bame, J. T. Gosling, R. D. Zwickl, and E. J. Smith	9949
Formation of Shock-Spike Events at Quasi-Perpendicular Shocks (Paper 3A1203)	Robert B. Decker	9959
Temporal Development of Diffuse Ion Events Upstream of the Earth's Bow Shock: The October 31, 1977, Event (Paper 3A1272)	George Skadron and Martin A. Lee	9975
Second-Order Effects Related to a Model for a Parallel Shock (Paper 3A1145)	R. W. Jackson	9981
Large Amplitude MHD Waves Upstream of the Jovian Bow Shock (Paper 3A1381)	Melvyn L. Goldstein, Charles W. Smith, and William H. Matthaeus	9989
Electric Field Measurements at the Magnetopause, 1, Observation of Large Convective Velocities at Rotational Magnetopause Discontinuities (Paper 3A1230)	F. L. Aggson, P. J. Gambardella, and N. C. Maynard	10,000
Dynamical Injections as the Source of Near Geostationary Quiet Time Particle Spatial Boundaries (Paper 3A1406)	B. H. Mauk and C. I. Meng	10,011
Characteristics of Storm Sudden Commencement at Geostationary Orbit (Paper 3A1591)	Susumu Kokubun	10,025
The Coupling of Shear Alfvén and Compressional Waves in High-β Magnetospheric Plasma (Paper 3A1340)	P. H. Ng and V. L. Patel	10,033
Relation of Compressional HM Waves at Ogo 2 to Low-Latitude Pc 3 Magnetic Pulsations (Paper 3A0895)	Kiyohumi Yumoto and Takao Saito	10,041
A Theoretical Model Study of Observed Correlations Between Whistler Mode Waves and Energetic Electron Precipitation Events in the Magnetosphere (Paper 3A1545)	H. C. Chang and U. S. Inan	10,053
Cyclotron Maser Emission of Auroral Z Mode Radiation (Paper 3A1483)	R. G. Hewitt, D. B. Melrose, and G. A. Dulk	10,065
Emission of Second-Harmonic Auroral Kilometric Radiation (Paper 3A1401)	C. S. Wu and T. M. Qiu	10,072
Comparison of the Characteristics of Potential Drop and Current-Driven Double Layers (Paper 3A1311)	Nagendra Singh and R. W. Schunk	10,081
Electromagnetic Theory of Collisional Interchange Instabilities (Paper 3A1474)	A. J. Hintzman and J. L. Sperling	10,091
Pedersen Density Drift Instabilities (Paper 3A1432)	S. Peter Gary and Thomas E. Cole	10,104
Sondrestrom Measurements of High-Latitude Ionospheric Convection (Paper 3A1507)	R. A. Heelis, J. C. Foster, O. de la Beaujardiere, and J. Holt	10,111
Polar Cap Electron Densities From DE 1 Plasma Wave Observations (Paper 3A1486)	Ann M. Persoon, Donald A. Gurnett, and Stanley D. Shawhan	10,123
Incoherent Scatter Measurements of Ion-Neutral Collision Frequencies and Temperatures in the Lower Thermosphere of the Auroral Region (Paper 3A1346)	Chantal Lathuillere, Vincent B. Wickwar, and Wlodek Kofman	10,137
An Analysis of the Spatial Distribution of Dayside Cleft Optical Emissions (Paper 3A1289)	R. Link, J. C. McConnell, and G. G. Shepherd	10,145
O(¹S) From Dissociative Recombination of O_2^+: Nonthermal Line Profile Measurements From Dynamics Explorer (Paper 3A1382)	J. J. Killeen and P. B. Hays	10,163
A Revised Thermospheric Model Based on Mass Spectrometer and Incoherent Scatter Data: MSIS-83 (Paper 3A1405)	A. E. Hedin	10,170
Some Observational Constraints on the Global-Scale Wind Systems of Mars (Paper 3A1118)	Ralph Kahn	10,189
Possible Observation of a Disconnected Magnetic Structure in a Coronal Transient (Paper 3A1447)	R. M. E. Illing and A. J. Hundhausen	10,210
Measurements of the Solar Flux at 220 nm (Paper 3A1155)	Frederick A. Hamrr and Rich Sellers	10,215
A Reexamination of ATS 6 Magnetometer Data for Radially Polarized Pc 5 Magnetic Pulsations (Paper 3A1476)	Kazue Takahashi and Robert L. McPherron	10,223
First Ground-Based Observations of Siple VLF Transmitter Signals Outside the Plasmapause (Paper 3A1309)	D. L. Carpenter and J. R. Miller	10,227
Geomagnetic Variations in Plasmaspheric Thermal Ion Composition (Paper 3A1551)	N. J. Miller, H. G. Mayr, and I. Harris	10,233
Observations of the High-Latitude Ionosphere With the Poker Flat MST Radar: Analyses Using Simultaneous Chatanika Radar Measurements (Paper 3A1406)	J. G. Lahmann, R. M. Johnson, M. J. Baron, B. B. Balsley, and A. C. Riddle	10,239
The 630- to 900-Å Spectrum of a Nighttime Aurora (Paper 3A1458)		10,247
The Dispersion of Traveling Ionospheric Disturbances (Paper 3A1157)	M. G. Morgan and D. L. Tedd	10,253
Equatorial Anomaly in Ionospheric Electron Content and Its Relation to Dynamo Currents (Paper 3A0509)	N. Balan and K. N. Iyer	10,259
Long-Wavelength Limit of the E × B Instability (Paper 3A1402)	J. D. Huba and S. T. Zalesak	10,263
Correction to "A Two-Dimensional Model of the Ionosphere of Venus" by T. E. Cravens et al. (Paper 3A1260)		10,266
Author and Subject Indexes Follow		10,266

Journal of Geophysical Research

Volume 88 Number B12 December 10, 1983

Title	Authors	Page
Measurements of Mantle Wave Velocities and Inversion for Lateral Heterogeneity and Anisotropy, 1. Analysis of Great Circle Phase Velocities (Paper 3B1409)	Ichiro Nakanishi and Don L. Anderson	10,267
Observations of Coupled Spheroidal and Toroidal Modes (Paper 3B1411)	Guy Masters, Jeffrey Park, and Freeman Gilbert	10,285
Autoregressive Harmonic Analysis of the Earth's Polar Motion Using Homogeneous International Latitude Service Data (Paper 3B1408)	B. Fong Chao	10,299
Direct Determination of Gravitational Harmonics From Low-Low GRAVSAT Data (Paper 3B1323)	C. A. Wagner	10,309
Global Upper Mantle Temperature Variations Consistent With Observed Heat Flow and Plate Velocities (Paper 3B1054)	William M. Kaula	10,323
Investigation of the Mechanism of the Olivine-Spinel Transition in Fayalite by Synchrotron Radiation (Paper 3B1451)	M. R. Furnish and W. A. Bassett	10,333
Thermoelastic Attenuation of Composite Materials (Paper 3B1450)	Bernard Budiansky, Erick E. Sumner, Jr., and Richard J. O'Connell	10,343
Criteria for the Resolution and Reconstruction of Acoustic Impedance (Paper 3B1407)	Philip M. Carrion and Waldo A. Patton	10,349
Slip Instability and State Variable Friction Laws (Paper 3B1216)	Andy Ruina	10,359
Regional Tectonic and Earthquake Hazard Implications of a Crustal Fault Zone in Southwestern Washington (Paper 3B1351)	Craig S. Weaver and Stewart W. Smith	10,371
Utilization of Seismically Recorded Infrasonic-Acoustic Signals to Monitor Volcanic Explosions: The El Chichon Sequence 1982—A Case Study (Paper 3B1452)	Frederick J. Mauk	10,385
Seismicity, Fault Plane Solutions, Depth of Faulting, and Active Tectonics of the Andes of Peru, Ecuador, and Southern Colombia (Paper 3B1259)	Gerardo Suárez, Peter Molnar, and B. Clark Burchfiel	10,403
An Anomalous Low Velocity Region Above the Deep Earthquakes in the Japan Subduction Zone (Paper 3B1179)	Kiyoshi Suyehiro and I. Selwyn Sacks	10,429
A Reevaluation of the Isostatic Rebound of Lake Bonneville (Paper 3B1278)	S. Mate Nakiboglu and Kurt Lambeck	10,439
Gravity Anomalies and Flexure of the Lithosphere at Mountain Ranges (Paper 3B1138)	G. D. Karner and A. B. Watts	10,449
Precision of Geodolite Surveys: A Reply to Jackson and Cheng (Paper 3B1322)	J. C. Savage and W. H. Prescott	10,478
Temperature Stratification and Refraction Errors in Geodetic Leveling (Paper 3B1412)	Roger H. Shaw and Peter J. Smietana, Jr.	10,485
Seismicity and Aseismic Slip Along the Eltanin Fracture Zone (Paper 3B1073)	Lisa M. Stewart and Emile A. Okal	10,495
Density and Size Distribution of Seamounts in the Eastern Pacific Inferred From Wide-Beam Sounding Data (Paper 3B1410)	Thomas H. Jordan, H. William Menard, and Deborah K. Smith	10,508
Geochemical Studies of Abyssal Lavas Recovered by DSRV *Alvin* From Eastern Galapagos Rift, Inca Transform, and Ecuador Rift, 1. Major Element Variations in Natural Glasses and Spatial Distribution of Lavas (Paper 3B1275)	Daniel J. Fornari, Michael R. Perfit, Alexander Malahoff, and Robert Embley	10,519
Geochemical Studies of Abyssal Lavas Recovered by DSRV *Alvin* From Eastern Galapagos Rift, Inca Transform, and Ecuador Rift, 2. Phase Chemistry and Crystallization History (Paper 3B1279)	Michael R. Perfit and Daniel J. Fornari	10,530
Geochemical Studies of Abyssal Lavas Recovered by DSRV *Alvin* From Eastern Galapagos Rift, Inca Transform, and Ecuador Rift, 3. Trace Element Abundances and Petrogenesis (Paper 3B1280)	Michael R. Perfit, Daniel J. Fornari, Alexander Malahoff, and Robert W. Embley	10,551
Inversion of Batch Melting Equations and the Trace Element Pattern of the Mantle (Paper 3B1449)	F. Albarède	10,573
Late Cretaceous–Early Tertiary Tectonic History of Southern Central America (Paper 3B1353)	Wolf-Achim Kolarsky	10,585
Paleomagnetism of the Late Cretaceous–Early Tertiary North-Central Montana Alkalic Province (Paper 3B1209)	J. F. Diehl, M. E. Beck, Jr., S. Beske-Diehl, D. Jacobson, and B. C. Hearn, Jr.	10,593
Paleomagnetism of Two Late Pleistocene Lake Basins in Colorado: An Evaluation of Detrital Remanent Magnetization as a Recorder of the Geomagnetic Field (Paper 3B1257)	J. G. Rosenbaum and R. L. Larson	10,611
Use of the Magnetotelluric Method for a Better Understanding of the West African Shield (Paper 3B1256)	M. Ritz	10,625
Spectral Properties of Mixtures of Montmorillonite and Dark Carbon Grains: Implications for Remote Sensing Minerals Containing Chemically and Physically Adsorbed Water (Paper 3B1065)	Roger N. Clark	10,635
Correction to "Contrast of Metamorphic and Structural Histories Across the Work Channel Lineament, Coast Plutonic Complex, British Columbia" (Paper 3B1509)	Maria Luisa Crawford and Lincoln S. Hollister	10,647
Correction to "The Deformation, Gravity, and Potential Changes due to Volcanic Loading of the Crust" (Paper 3B1281)		10,652
Author and Subject Indexes Follow Page		

Physical Properties of Rocks

6110 Elasticity, fracture and flow
THE EFFECT OF TEMPERATURE AND IMPURITY CONTENT ON INDENTATION HARDNESS OF QUARTZ
Brian Evans ...
[illegible]

Seismology

5505 Body Waves (Seismology)
[illegible] (P-wave, amplitude, attenuation, temperature).

Rev. Geophys. Space Phys., Paper 3R1817

6950 Seismic Sources
AMPLIFICATION OF MOMENT AND STRAIN ENERGY RELEASE DUE TO INTERACTION BETWEEN DIFFERENT SIZE FAULT SLIP ZONES
J.W. Rudnicki ... and J.R. Kanamori
[illegible]

J. Geophys. Res., Earth, Paper 3B1778

6950 Seismic sources
ROUGHNESS AT THE BASE OF THE SEISMOGENIC ZONE: CONTRIBUTING FACTORS
R. H. Sibson (Department of Geological Sciences, University of California, Santa Barbara, California, 93106)
[illegible]

J. Geophys. Res., Earth, Paper 3B1724

0960 Strong Motion
A FAULTING MODEL FOR THE 1979 IMPERIAL VALLEY EARTHQUAKE
Archuleta, Ralph J. (U.S. Geological Survey, 345 Middlefield Road, MS 77, Menlo Park, CA 94025)
[illegible] specification of the rupture time. Although the slip rate amplitudes are linearly related to the data, the rupture time and the duration are not. The parameterization of the nonlinear variables has a strong effect on the generation of synthetic seismograms from a finite fault. (Earthquake, Strong Motion, Modeling, Imperial Valley).

J. Geophys. Res., Earth, Paper 3B1760